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OPERATING AND SERVICING MANUAL

MODEL 100

GAUSSMETER

FW BELL INC.
ELECTRONIC DESIGN • DEVELOPMENT • MANUFACTURING
COLUMBUS, OHIO

OPERATING AND SERVICING MANUAL

MODEL 100

GAUSSMETER

F. W. BELL, INC.
1356 Norton Avenue
Columbus 12, Ohio
Phone AX-4-4906

INSTRUCTIONS FOR MODEL 100 GAUSSMETER

The Model 100 Gaussmeter was designed to provide a convenient direct indicating instrument for the measurement and plotting of magnetic fields. It reads constant or D.C. magnetic fields - or slowly varying ones - and will reject alternating fields.

TECHNICAL DATA

Meter ranges are as follows:

0 - 300 Gauss
0 - 3 Kilogauss
0 - 30 Kilogauss

Calibration accuracy is ±2% of full scale with reference to standard magnets at the F. W. BELL, INC. laboratories. Repeatibility of readings is usually better than 1%.

Higher accuracy can be obtained by using calibrated reference magnets available from F. W. BELL, INC.

At 14 Kilogauss and above the inherent non-linearity of the indium arsendie sensing element causes a reduction in meter indication. A calibration curve can be used to obtain approximately 5% overall accuracy above 14 KG.

The temperature coefficient of the indium arsenide sensing element is nominally 0.1% per deg C. The Gaussmeter is intended for operation in ambient temperatures ranging from minus 25°C to plus 35°C.

The sensing element is enclosed within a retractable metal tube and is mounted in neroprene, for protection against forces applied to it in handling. When exposed, the element is .019 ± .002 inch thick, .120 to .130 inch wide, and extends out beyond the mount by 5/16 inch. The actual sensing area is equivalent to approximately a 1/16 dia. circle whose center is 1/8 inch from the end of the element. The element itself is non-magnetic and it's effect on the field being measured is nil. It is mounted on the end of an extension tube which is plug-in to the end of the probe handle. Probe cable is five feet in length.

Power is supplied by means of a self contained 4-1/2 V battery (NEDA 3) such as Eveready #736. Current drain is 300 ma when the probe push-button is depressed. Battery current is regulated at 300 ma by means of an amperite #3TK2.

Overall dimensions - 10-1/8" wide
4-3/4" deep
7-1/2" high
Shipping weight - 6 pounds 8 ounces.

DAMAGE IN TRANSIT

The unit and shipping carton should be carefully examined immediately to determine possible damage in shipment. If evidence of damage is found call Railway Express Agency or the agent of the carrier who made delivery and request an inspector to view the damage and fill out a report. Keep all of the shipping carton parts as received for the inspector to see. Mail a copy of the report to us, F. W. BELL, INC., 1356 Norton Avenue, Columbus 12, Ohio, and at the same time forward the damaged contents via Railway Express collect. Do not send via Parcel Post. Pack the unit for return shipment in the original carton, if possible, and at least as well as the original pack so as not to incur further damage in the return shipment. Upon receipt of the claim report and the unit we will repair or replace with as little delay as possible, and within the terms of our warranty.

GENERAL DESCRIPTION

This instrument is a ruggedly built, sensitive and accurate meter for the direct indication of magnetic flux density in Gauss. It operates on the Hall effect principle and uses a very thin wafer of indium arsenide as the sensing element. The indium arsenide is in turn mounted upon an extremely thin glass plate to permit electrical connections to be made to the element. The overall thickness of this element is so small as to permit it to be placed in very narrow gaps for magnetic field strength exploration.

The element is direction-sensitive so that the probe has to be reversed if a reverse meter deflection is obtained. The element is obviously very fragile and every attempt has been made to protect it against breakage in use. It is strain sensitive, and no forces should be applied directly to the element in the measuring process. If a large number of measurements are to be taken in a narrow gap, it is advisable to mount the probe on a stand, correctly positioned so that the element can enter the gap, be held there and withdrawn without the possibility of developing a mechanical strain on the element. The element is shipped with a metal outside protective tube 3/16 O.D. completely surrounding it. This tube is magnetically transparent to steady fields and NEED NOT BE WITHDRAWN unless it is necessary. To expose the element, release the small spring by pressing down and push the outside tube back over the spring. Always keep in mind that the meter is reading the component of flux density which is perpendicular to the surface of the sensing element. If the element is not held at right angles to the direction of the flux vector, the meter will indicate the actual flux multiplied by the cosine of the angle from the perpendicular. Note that the element is mounted to be horizontal when the small release spring is held upward.

For further protection, the element is mounted in neoprene pads. These pads will absorb a reasonable amount of bending or twisting force applied to the element so that with care, damage to the element is very unlikely.

In case breakage does occur, refer to the section on maintenance for replacement instructions. THE OUTER PROTECTIVE SLEEVE SHOULD BE KEPT IN PLACE OVER THE ELEMENT AT ALL TIMES EXCEPT IN ACTUAL USE, AND THEN ONLY WHEN THE ELEMENT MUST BE EXPOSED.

An important design advantage is the long-time stability of the element and simplicity of the circuitry. No amplifier is required due to the high Hall voltage coefficient of the element. No "balance" controls or "zero" adjust knobs are needed because of the excellent stability of the element.

OPERATION

The operation of the instrument is extremely simple, it being only necessary to depress the red push-button on the probe handle to energize the unit from the built-in-battery. No current is drawn from the battery until the push-button is depressed, consequently battery life is largely a matter of how long the button is held on.

All of the internal calibration adjustments have been made at the factory and should not need further adjustment.

A CAL position is included on the selector switch for the purpose of indicating that the battery current is correct to maintain calibration. In the CAL position a full scale meter deflection - when the probe push-button is depressed - indicates correct current. The reading actually is the voltage developed in the sensing element due to the flow of controlled battery current. Since magnetic flux readings are also proportional to battery current (as well as the magnitude of the flux being read) the CAL reading is a direct indication of the maintenance of calibration.

Note the CAL meter reading with the fresh battery supplied. It should be within plus or minus 2% of full scale - ALLOW two (2) seconds until reading stabilizes. When the battery becomes discharged to the point where the regulated current falls by 2% or more (6 Gauss in CAL position) the battery should be replaced. See section on Maintenance.

Note that there is an inherent time lag of about two (2) seconds for the pointer to come to rest at a particular reading. This time should be allowed before taking a reading. The probe push-button should be held down only as long as readings are being taken for maximum battery life. If necessary, however, the button can be clamped closed and a separate switch wired in series with the battery.

For readings above 14 Kilogauss, the calibration curve included on the last page of this manual, should be used for greater accuracy. The sensing element is plug-in to a special four (4) contact socket in the end of the probe handle. Special probes designed for particular applications are available on special order and may be plugged into the handle. See the section on Maintenance for instructions. Each Gaussmeter is internally calibrated at the factory for the characteristics of the particular probe with which it is to be used.

MAINTENANCE

In the event of breakage of a probe element, it is advisable to return the instrument to the F. W. BELL, INC. factory for a replacement and recalibration. However, it is possible to make field replacement by the following procedure, provided standard magnetic fields are used for recalibration.

(See rear view for location and resistance values of adjustment).

1. INSTRUCTIONS FOR REPLACEMENT OF PROBE

(a) Set range switch to 300 Gauss position.

(b) Remove damaged probe by un-plugging connector plug at front end of probe extension tube and pull to remove. Do not press red button.

(c) Replace with new probe tip by plugging in, noting that connector is keyed so that plug can only be inserted one way. Do not push end of tip, make certain protective sleeve is in place over probe tip.

2. CALIBRATION PROCEDURE

NOTE: This procedure is used for maintenance calibration and when the probe is changed.

The calibration of the Model 100 Gaussmeter is carried out with the aid of reference magnets. These magnets are pre-aged and stabilized to a particular field strength at the gap. They are available from F. W. BELL, INC., in values of -

Model VA070 - 300 - Gauss
Model VA072 - 3 - K Gauss
Model VA074 - 14 - K Gauss

Intermediate values are also available.

The calibration procedure is as follows: (SEE REAR VIEW GAUSSMETER)

(a) Remove the back panel from the instrument by removing four (4) Phillips head screws around the edges. Do not un-plug the battery.

(b) ZERO ADJUSTMENT - Looking into rear of instrument the zero adjustment is the upper right hand rheostat. Insert a small screw driver into center slot of rheostat - hold red button down on probe handle and adjust until meter reads zero. Range switch must be in 300 Gauss position and probe out of magnetic field.

(c) CAL ADJUSTMENT - Place range switch in CAL position, press red button and adjust bottom rheostat until meter indicates full scale.
NOTE: Allow at least two (2) seconds for correct indication.

(d) Calibration of the 300 Gauss range - Place the range switch in the 300 Gauss range, depress the red button and hold the probe in the 300 GAUSS reference magnet. If the magnet has been calibrated to a value slightly under the exact full scale figure, always use the calibrated value. Adjust the calibration rheostat, see REAR VIEW DRAWING for the 300 Gauss scale, until the meter indicates the calibrated value of the reference magnet.

NOTE: Due to the fact that the element is direction-sensitive, it will be necessary to rotate the probe in the field for a MAXIMUM READING. Move the probe also back and forth to vary the depth of insertion in the magnet gap for a MAXIMUM READING. The proper position in the magnet gap is in the exact center of the gap. It is advisable to clamp the red push-button down to hold the unit ON during the calibration procedure. After adjusting the calibration control, again insert the probe in the magnet and align it for a MAXIMUM READING. The reading should agree with the calibration value of the magnet. Tap the meter lightly with the finger tip to overcome any meter friction that may be present.

(e) Repeat this calibration procedure for the 3 KG range, using a 3 KG reference magnet.

(f) Repeat above on 30 KG range using the 14 KG magnet. The 14 KG magnet is used because the Model 100 has been linearized up to 14 KG and is most accurate at this point.

3. INSTRUCTIONS FOR BATTERY REPLACEMENT.

To replace the battery remove the back panel as described above and un-plug the battery. Note that the battery is clamped to the back panel with two (2) long bolts and a cross bracket. Remove old battery and replace in exactly the same manner using the crush pads along the edges of the battery and clamp. DO NOT TIGHTEN THE BOLTS TOO TIGHT. Use Eveready #736 or equal.

4. OPERATING DETAILS AND TROUBLE-SHOOTING INFORMATION.

(a) The sensing element, mounted at the end of the probe tip, consists of a small sliver of semiconductor material with four (4) electrical connections made to it. The element is almost square in shape with connections made to the center of each of the four (4) sides. Two (2) connections on opposite sides are "current" leads, providing a flow of battery current (250 ma) thru the semiconductor "Hall" element and the other two (2) are voltage output leads. A D.C. voltage appears across the voltage leads of the semiconductor crystal when it is placed in a magnetic field. The voltage produced across the element is due to the deflection of charge carriers (current) in the crystal by the magnetic field. The amount of voltage developed is directly proportional to the strength of the magnetic field. This relationship of output voltage to magnetic flux density is a linear (straight line) relationship up to a point, then the output voltage begins to deviate (at high flux densities) and the system becomes non-linear.

The Hall element is very low resistance. The resistance across the current leads should be 1 to 2 ohms D.C. The resistance across the voltage leads should be .6 ohm to 1.5 ohms or about 60% of the resistance across the current leads. A resistance measurement from one current lead to one voltage lead should give a value in between the resistance of the current pair and voltage pair. The Hall element is mounted on a thin glass plate and is extremely fragile. It can be fractured or broken in normal handling unless care is used. A fracture too small to be visible will cause erratic operation of the instrument while only slightly changing the resistance of the element.

(b) The probe is plug-in to the probe handle using a four (4) contact miniature plug with gold plated sliding type contacts. The probe handle contains the socket, operating push-button and the (10 ohm) linearizing resistor. The push-button is wired in series with the current supply from the battery to the Hall element.

The linearizing resistor is connected across the current terminals of the Hall element and shunts a fraction (about 15%) of the current from the element. Since the resistance of the Hall element changes at high flux densities due to the magnetoresistance effect, the fraction of current shunted by the resistor changes in a direction to improve the output voltage linearity.

(c) The remainder of the circuitry consists of a resistance balancing arrangement, a current regulating Amperite, a meter and the necessary series - connected meter range resistors used to calibrate the various scales. Also, a 40 ohm resistor is provided as a load across the meter to "damp" the pointer (electrical damping of the meter movement) on all but the 300 gauss scale. The balancing potentiometer (100 ohm pot.) is required because there is normally a small output voltage from the Hall element, when current flows thru it, even in a zero magnetic field. The Hall element can be considered as a four (4) terminal electrical resistance bridge, which is thrown out of balance by the magnetic field. This "bridge", however, is not perfectly balanced to start with due to manufacturing tolerances. Therefore, an external resistor must be provided for external balance of each element. This is a zero field adjustment for electrical zero on the meter.

The 100 ohm pot is connected across the voltage terminals with the arm on one of the current leads. Whenever this pot must be adjusted near one end, and the adjustment is very critical, a poor connection, open circuit or fractured element is usually the cause. Normally it will adjust somewhere near center rotation. The meter is a four (4) millivolt full scale meter having 10 ohms internal resistance. It therefore requires .4 milliampere for full scale deflection. The 40 ohm meter shunt resistor requires .1 milliampere for full scale making a total of .5 milliampere for meter and shunt. The Hall element puts out about 20 millivolts in a 1 KG field. The total circuit resistance for .5 ma would then be 40 ohms. Subtracting resistance of meter, element, leads, etc., leaves about 28 ohms for the meter calibrating resistance for a 1 KG scale. The adjustment range is designed to take care of variations in the value of regulated current, Hall voltage output as well as meter and other tolerances.

In the CAL position, the meter is connected thru a suitable series adjustment rheostat across one of the voltage and current leads of the Hall element. This means that it will read the voltage drop in the resistance of the Hall element due to the flow of regulated battery current. This reading is always taken in zero magnetic field.

Since the resistance of the Hall element is very stable in value, the meter reading is actually dependent upon the amount of current flowing thru the element. It is therefore a good indication of whether the current is holding up, i.e., if the battery is still good and if the battery voltage is still within the regulating range of the Amperite. The Amperite will hold the current constant until the battery voltage drops to 3 volts, or slightly less.

(d) When the Gaussmeter push-button is pressed, a period of a few seconds must be allowed before taking a reading. This is because of a current transient during the warm-up time of the Amperite. Also, there is some heating as current flows thru the Hall crystal causing a temporary shift in its resistance balance. This effect should not be serious, amounting only to about 10 gauss or less on the meter. An extremely high transient indicates a defective Amperite or fractured Hall crystal.

The Hall element can also be unbalanced by allowing cold metal (or hot metal) to come into contact with the sensing element, particularly along one edge.

(e) No meter indication, or low indication, can be caused by an open circuit or high resistance in the meter circuit or in the current circuit to the Hall element. If the meter bangs full scale, look for a severe unbalance of the Hall element due either to a fractured element, or a poor contact at the connector socket, or the balancing pot is rotated too far toward one end.

If the meter bangs in the CAL position, look for a poor joint in the current circuit or a fractured element causing the voltage drop to be excessive. Of course, the meter will go over full scale if any of the series adjust resistors is set to too low a value.

(f) The minature plug and socket on the probe should be checked whenever intermittent operation is obtained, or an open circuit is suspected. The contacts must be kept clean (polish with dry cloth) and the plug contacts should have a small amount of "spring". The contacts are tempered, therefore are brittle and break easily. Carefully clean away deposits of dirt and cement underneath the contacts. Make sure they are aligned properly, and that the plug and socket fit together firmly. The probe handle is dis-assembled by removing the #6 Allen set screw on the under side of the front piece. When replacing, the cut-away portion of the handle tube must be centered on the push-button switch and clear it. Maintain pressure of the handle tube against the front portion when tightening the set screw.

5. TABLE OF REPLACEABLE PARTS.

1-	Standard Probe Assembly (plug-in)	YA029
1-	Meter	MA021
1-	Battery, 4-1/2 V NEDA-3, Marathon #3003, Eveready #736	
1-	Probe Handle Assembly, with cable	YA030
1-	Knob-Switch	KA023
1-	Regulator, Amperite #3TK2 factory aged	
1-	Switch, Rotary Range	SA002

WARRANTY

"F. W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Out obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except the probe element and batteries (these parts are covered by a standard EIA 90 day warranty) which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which on our examination shall disclose to our satisfaction to have been thus defective.

F. W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F. W. BELL, INC., and F. W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F. W. BELL, INC. instruments."

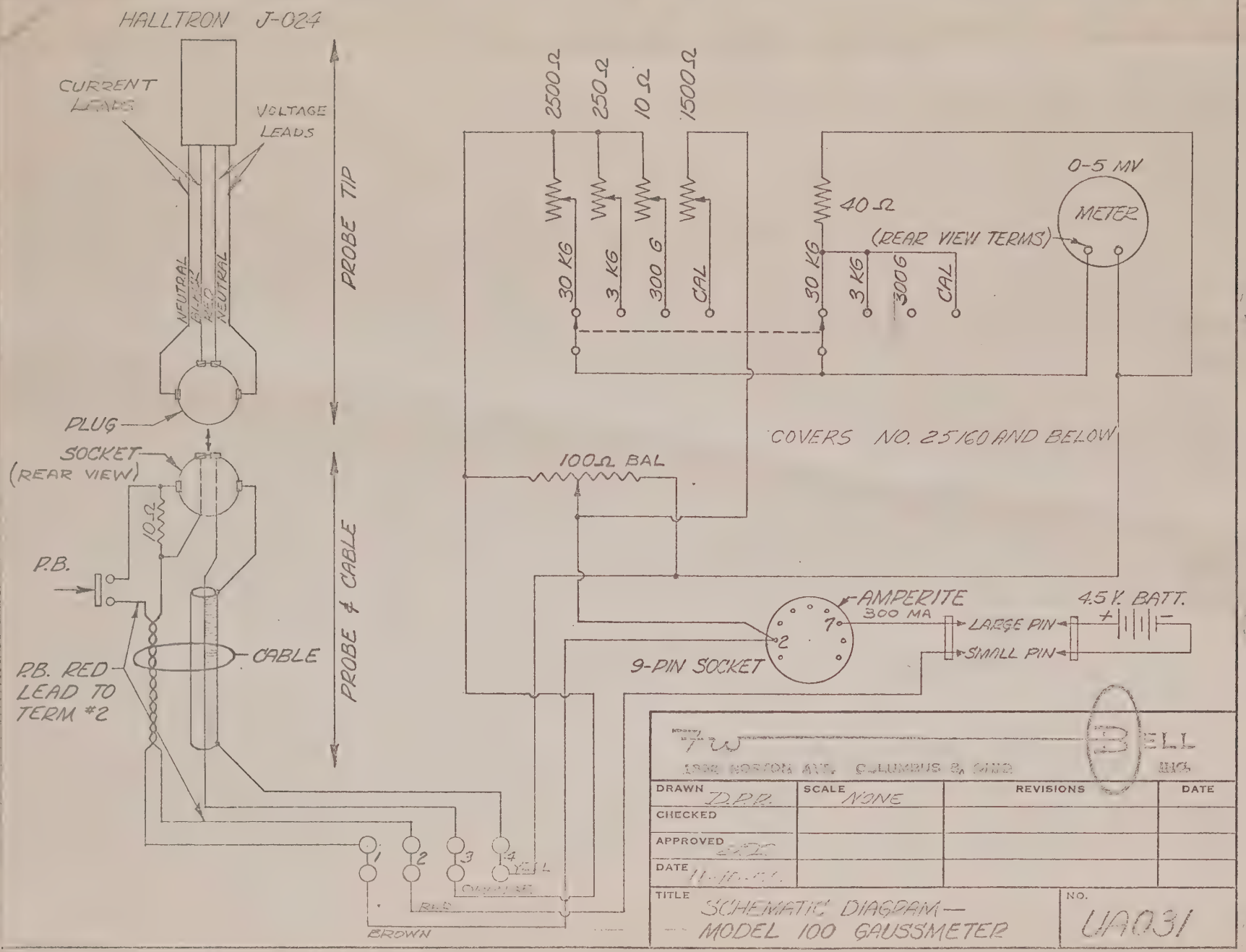
STOCK LIST OF REPLACABLE PARTS AND CALIBRATION MAGNETS

Model 100 Gaussmeter (including accessories)

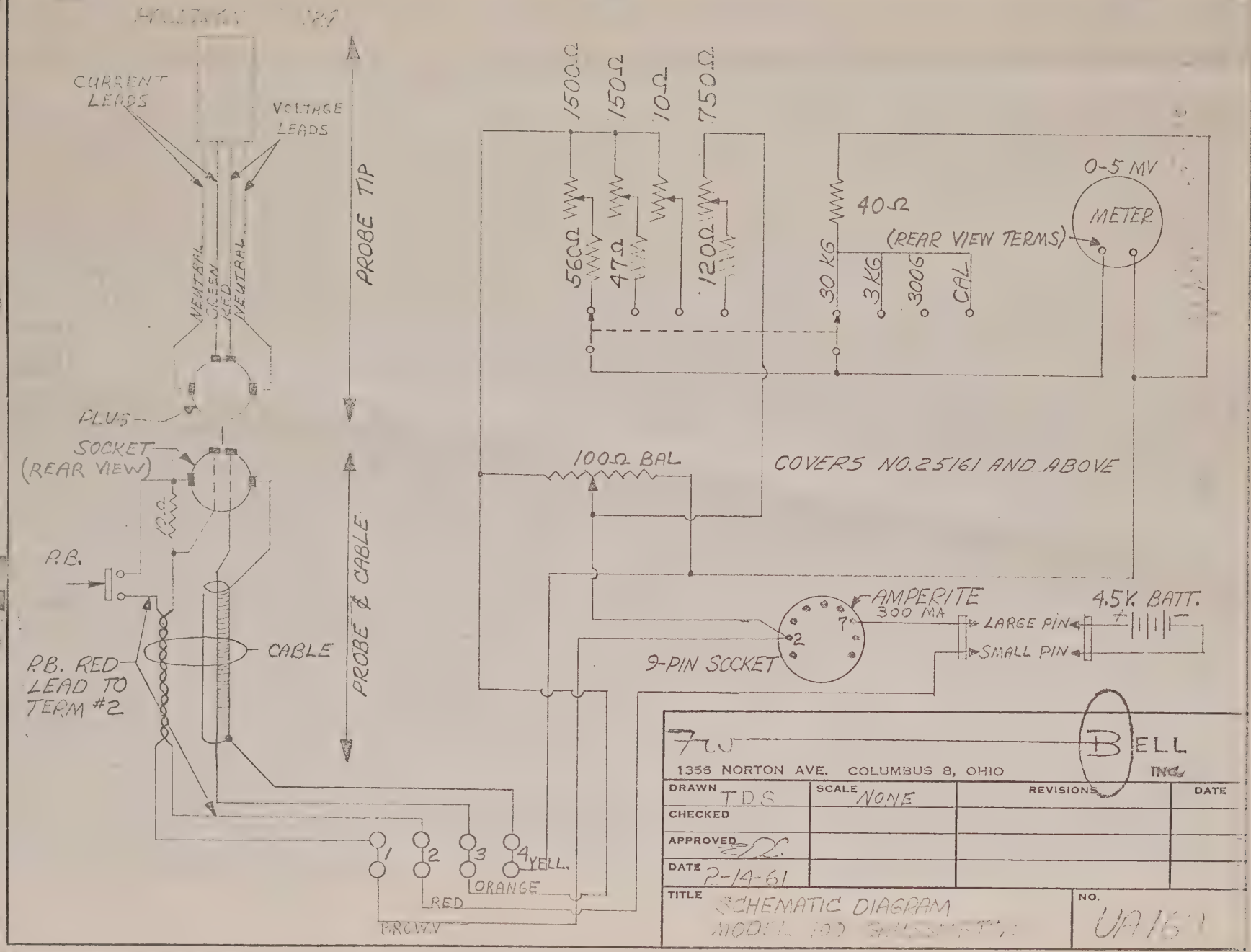
Suggested Quantity	Part No.	Description	Net Price
1	VA-070	300 Gauss Reference Magnet	$50.00
1	VA-071	1000 Gauss Reference Magnet	$50.00
1	VA-072	3 KG Reference Magnet	$50.00
1	VA-073	10 KG Reference Magnet	$75.00
1	VA-074	14 KG Reference Magnet	$75.00
2 to 4	YA-029	Transverse Probe Assembly	$60.00
1 to 2	YA-060	Axial Probe Assembly	$85.00
1 to 2	MA-021	Meter	$32.50
4 to 6		4-1/2 volt Battery - NEDA #3 or Burgess #736 or Marathon #3003	
2 to 4	KA-023	Knob	.30
2 to 4		Tube, regulator, Amperite #3TK2, factory aged	2.50
2 to 4	SA-002	Switch, rotary function, 4 position	1.25
2 to 4	A-061	10 ohm rheostat	.50
2 to 4	A-062	250 ohm rheostat	.50
2 to 4	A-063	2500 ohm rheostat	.50
2 to 4	A-064	1500 ohm rheostat	.50
2 to 4	A-065	100 ohm potentiometer	.50
2 to 4	951	Switch, push button	.75

NOTE: All prices F.O.B. Columbus, Ohio
Terms: Net 30 days.

Prices subject to change without notice.



CHARLES BRUNING CO., INC. NO. 557 KOVEL



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1356 NORTON AVE. COLUMBUS 8, OHIO

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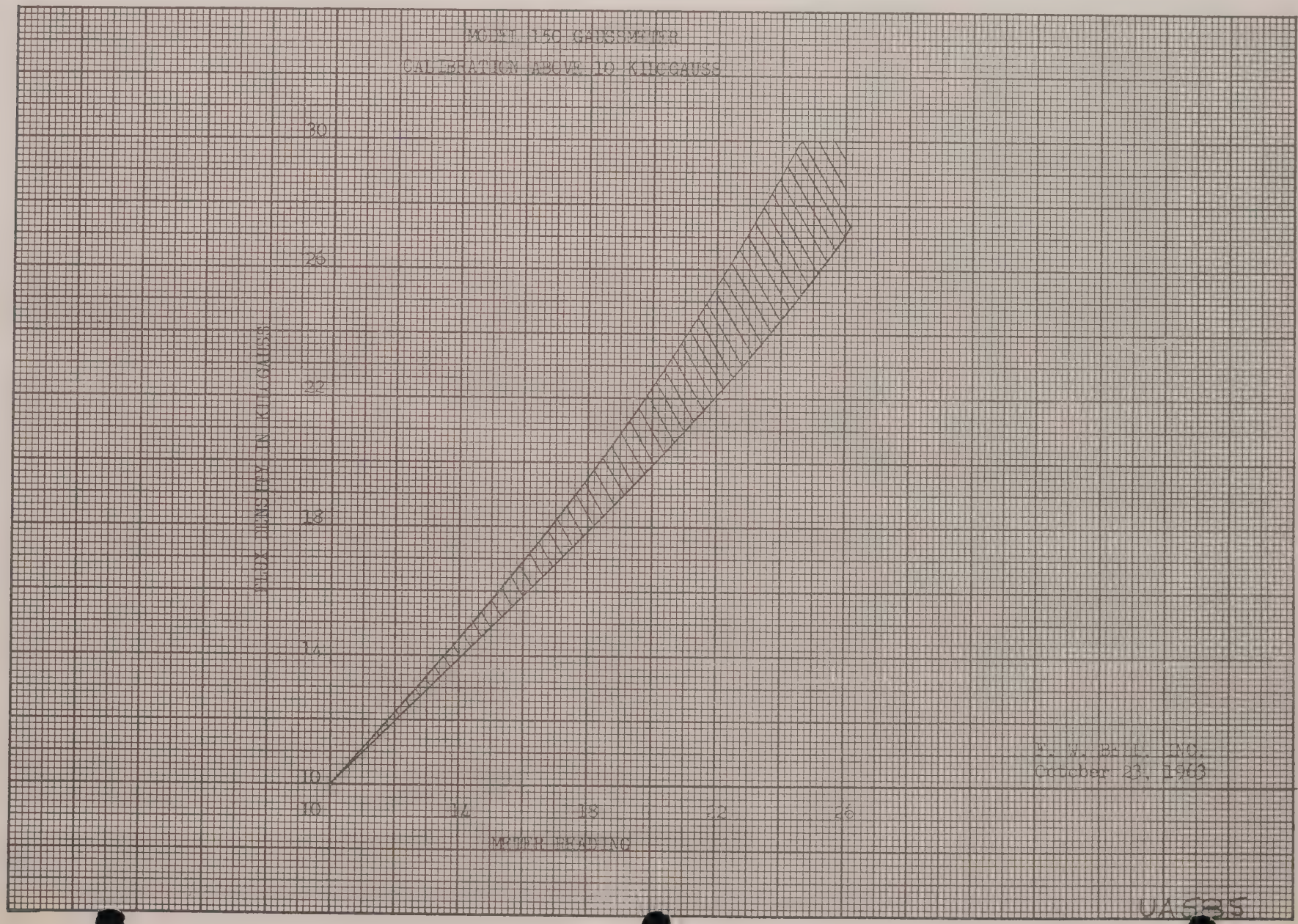
MODEL 150 GAUSSMETER
CALIBRATION ABOVE 10 KILOGAUSS
FLUX DENSITY IN KILOGAUSS
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METER READING
F. W. BELL INC.
October 23, 1963
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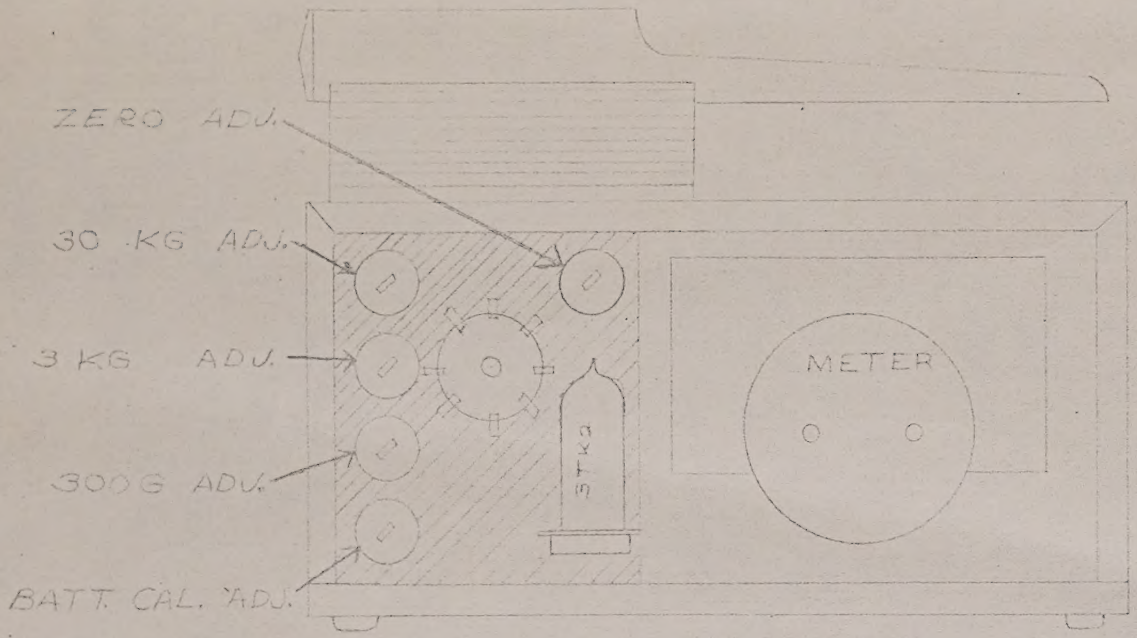

REAR VIEW - GAUSSMETER
MODEL 100

F. W. BELL, INC.

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